RIVER WATER QUALITY PERFORMANCE FROM CARBONDEOXYGENATION RATE

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ABSTRACT: The performance of river quality should always be observed in the river conservation. In this study the quality of river water is depicted from the rate of carbon deoxygenation. The rate of carbon deoxygenation indicates the speed of the dissolved oxygen consumption of the stream for the biochemical process of organic matter. Its value depends on the content of organic matter and the availability of oxygen from the reaeration capability of the stream. This research was conducted on the Metro River from Sukun sub-district of Malang to Kepanjen Sub-district, Malang Regency which is divided into 5 (five) segments. The method of determining carbon deoxygenation rate using Thomas method. The highest rate of carbon deoxygenation (*kd*) occurs in 4th segment of 0.63 / day, while the smallest is in 2nd segment of 0.48/day. The carbon dioxygenation rate in Metro River is higher than Brantas River of Malang City, Upper Citarum River, Cikapundung River and Citepus River. This shows that Metro River has better self-purification capability so that its quality is better.

Keywords: River quality, carbon deoxygenation rate, oxygen, river capability of self purification.

1. Introduction

The quality of river water in Indonesia has not shown a marked improvement despite management efforts. By year 2015 nearly 68 percent or the majority of river water quality in 33 provinces in Indonesia is in seriously polluted status (Kompas news). Assessment of the status of river water quality based on the Class II Water Quality Criteria is contained in the attachment of Government Regulation on Water Quality Management and Water Pollution Control (PP 82/2001). When viewed from the previous year, the quality of polluted river water has decreased. In 2014 no less than 79 percent of the river's status is heavily polluted. Along with this decline, the percentage of rivers that are in moderate and lightweight status is automatically increased in 2015. Although rivers that are categorized as heavy polluted have decreased, but the percentage is still very high.

In general, domestic effluent from wastewater treatment plant is disposed of in nearby rivers. To date, the performance of river water quality management from domestic pollutant sources through communal wastewater treatment plant (WWTP) is still low and rivers are still in polluted condition. The results of Brantas river water quality analysis in Malang city during rainy season in April 2015 showed high DO (6.27-7.53 mg/L). While in the dry season in November 2015 the content of DO at the monitoring point at Muharto Bridge showed concentration of 1.2 mg/L and at the monitoring point location at Bumiayu Bridge of 2.6 mg/L. The existence of communal WWTP which discharges its effluent in Brantas river is one of the pollutant source of river. Generally the Dissolved Oxygen (DO) concentration is a seasonal concentration of average with a minimum concentration of 3 - 4 mg/L and a desired concentration of 5 - 7 mg/L (Palmer, 2001). The low value of this river DO is one of them caused by the Brantas river being a receiving river of communal effluent which still contains organic material (BOD, Biochemical Oxygen Demand and COD, Chemical Oxygen Demand) and high nutrient. Decrease in river DO due to the biochemical processes of organic matter is determined by the rate of carbon deoxygenation in rivers (Hendriarianti, 2015). The rate of deoxygenation indicates the rate of reduced oxygen per day for the decomposition of carbon-soluble organic matter in water. The value depends on the level of organic carbon material present in the river. So as to relate to the characteristics of organic matter dumped in the river. This level of carbon deoxygenation shows the self-recovery capability of rivers from organic matter. So that the rate of carbon deoxygenation can show the performance of river quality as well as the physical, chemical and biological parameters that have been used. The objective of this research is to determine rate of Carbon deoxygenation on Metro river. The research was conducted on Metro river from upstream of river in Tirto, Sukun, Malang to downstream of Dempok Bay, Kepanjen, Malang Regency.

2. Material and Method

In this research, Metro river is divided into five river segments as follows:

a. 1st segment was located on Jalan Tirto Mulyo, Kelurahan Merjosari–Jembatan Gantung jalan Pisang Agung. This segment is an upstream area of Metro river. Landuse at this segment are high density settlement. This segment location is 7˚ 56’16.34”S 112˚ 35’51.82”E until 7˚ 56’31.89”S 112˚36’0.55”E.

b. 2nd segment was located on Jembatan Gantung jalan. Pisang Agung–jalan Raya Wagir (Kebon Agung). This segment are rice fields and settlement area. Location of this segment is on 7˚56’31.89”S 112˚36’0.55”E until 7˚58’32.06”S 112˚36’25.87”E.

c. 3th segment was located on jalan Raya Wagir (Kebon Agung)–Pakisaji (Karang Pandan). Land use at this segment are high density settlement, rice fields and industry area. This segment is located on 7˚58’32.06”S 112˚36’25.87”E until 8˚01’6.53” S 112˚36’5.90”E.

d. 4th segment was located on jalan Pakisaji (Karang Pandan)–Pemandian Metro. Landuse at this segment are high density settlement, rice fields. This segment is located on 8˚01’6.53”S 112˚36’5.90”E until 8˚04’2.89”S 112˚35’35.8”E.

e. 5th segment was located on Metro swimming pool at jalan Kepanjen Karangkates–Teluk Dempok. Land use at this segment are high density settlement, rice fields and recreation area. This segment is located on 8˚ 04’2.89”S 112˚ 35’35.8”E until 8˚ 07’6.08”S 112˚ 33’6.90”E.

Map of research location is presented in Figure 1.

The method of sampling river water based on SNI 6989.57 : 2008 Sampling Method of Surface Water. Standard methods APHA.5210 B -1998 was used for BOD analysis with the time interval of observation every 5 days. Deoxygenation rate of carbon or *kd* was determined using the method of Thomas, a graphical analysis based on mathematical functions similarity (Oke and Akindahunsi, 2015).

3. Result and Discussion

Water quality Metro river for five days analysis of BOD (BOD_5) and twenty days BOD analysis (BOD_{20}) compared with water quality standard for river class 2 (BOD_{WQS}) from Governor regulatory of East Java No. 2 year of 2008 illustrated in Figure 2.

From Figure 2, the value of BOD_5 and BOD_{20} are bigger from water quality standard of BOD (BOD_{WQS}). High BOD_5 and BOD_{20} on Metro river in this research becomes from domestic point source as describe on early section. Organic contain in domestic wastewater that discharged on the river go through biochemical process and need oxygen for this process. Therefore the biochemical oxygen demand increases in river receiving domestic wastewater.

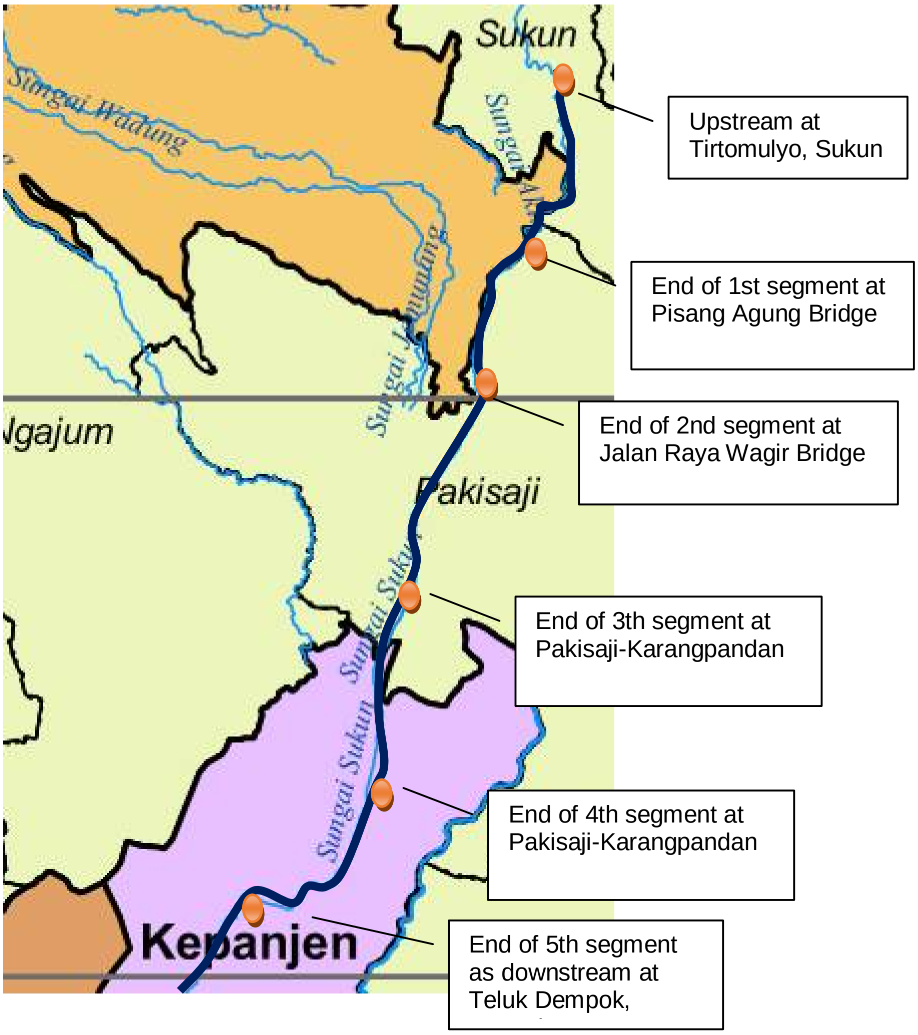

Figure 1 Segmentation of the River

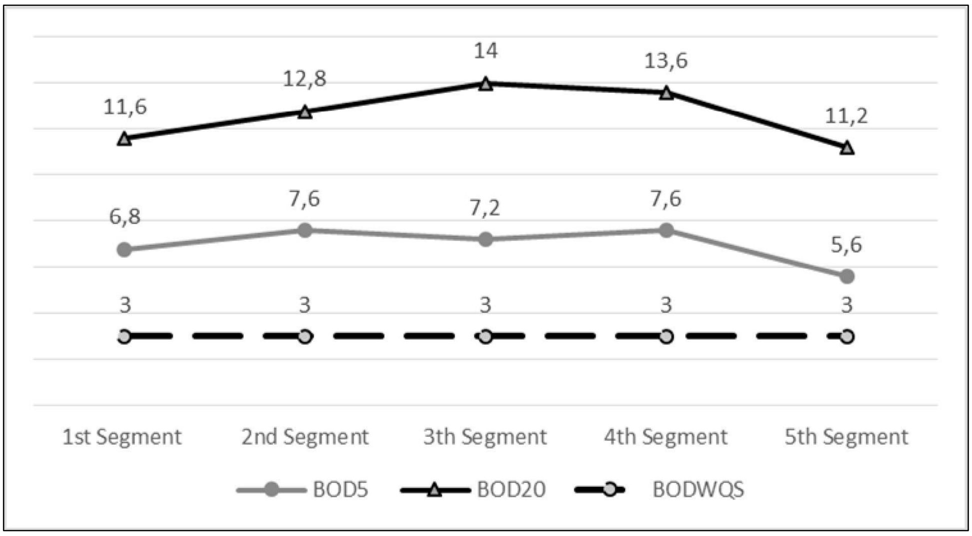

Figure 2 Comparation of BOD_5, BOD_{20} and BOD_{WQS}

The rate of carbon deoxygenation (*kd*) using Thomas method in each segment in Metro River from 1st segment to 5th segment can be seen in Table 1.

Table 1 Value of k and Lo for The River of Metro

No.	Locations	k_d value (/day)	R^2
1	Jalan Tirto Mulyo, Kelurahan Merjosari – Jembatan Gantung jalan Pisang Agung	0.54	0.873
2	Jembatan Gantung jalan. Pisang Agung – jalan Raya Wagir (Kebon Agung)	0.48	0.873
3	Jalan Raya Wagir (Kebon Agung) – Pakisaji (Karang Pandan)	0.55	0.873
4	Jalan Pakisaji (Karang Pandan) – Pemandian Metro.	0.63	0.873
5	Metro swimming pool at jalan Kepanjen Karangkates – Teluk Dempok	0.45	0.873

The carbon deoxygenation (*kd*) value from 1st segment to 5th segment of Metro River ranges from 0.45/day to 0.63/day. The result of carbon deoxygenation (*kd*) value in Metro River is compared with other rivers in Indonesia such as Citarum River, Cikapundung River, Citepus River in West Java and Brantas River in Malang city. The carbon deoxygenation value in Brantas River of Malang City ranged from 0.019/day to 0.046/day (Hendriarianti, 2015). The deoxygenation value of carbon (*kd*) Upstream Citarum River that ranges from 0.169/day to 0.482/day (Harsono, 2010). While on the Cikapundung River of 0.01/day to 0.37/day and Citepus River of 0.031/day to 0.48/day (Yustani, 2016). It is obtained that the value of carbon deoxygenation (*kd*) in the Metro River ranges from 0.45/day to 0.63/day that is greater than Brantas River Malang City and Citarum Upstream River. The high value of carbon deoxygenation in Metro River from Brantas River of Malang City and Upper Citarum River shows that the decomposition process of organic material in Metro River has occurred rapidly (Yustani, 2016). In addition, it also shows the greater ability of the river to oxidize and purify naturally (Faiz, 2010).

The highest carbon deoxygenation (*kd*) value found in 4th segment shows that the rate of oxygen consumption is relatively fast and the decomposition process in this segment occurs rapidly as well. This situation causes the dissolved oxygen to decrease rapidly to become lower (Faiz, 2010). The high value of *kd* in 4th segment is also due to the influence of the river's ability to perform self purification (Razif, 1994). The river has the ability to recover itself (self purification) from the contaminants through the oxidation process with oxygen from the reaeration process (Agustiningsih, et al., 2012). Factors that affect the ability of self-recovery of the river such as the rapid flow, the amount of discharge and the level of waste contained in river water (Fadly, 2008; Hung, et.al., 1978). The effluent quality of WWTP and the receiving stream flow also determines the rate of carbon deoxygenation. The value of *kd* increases with the higher quality of effluent WWTP and the lower flow of the receiving stream. The self-purification capability of the river is also influenced by the level of waste contained in river water. The high value of *kd* in 4th segment is due to the level of incoming waste still fulfill the capacity of the river so that the river is still able to perform self-recovery (self purification).

The flow of Metro River has increased significantly from upstream to downstream. This is because the addition of flow from the pollutant source in the previous segment becomes a factor that accelerates the discharge at the research location. The amount of the river water discharge will affect the concentration of pollutants in water. In river water that has a large debit, the concentration of pollutants will decrease due to dilution. Conversely, in river water with a small discharge the concentration of pollutants in water will be higher (Maharthika, 2016). Another factor leading to high *kd* values is the effect of the characteristic of the rocky Metro River causing natural filtering in the Metro River (Ali, 2013; Maharthika, 2016).

The value of carbon deoxygenation constants (*kd*) having similar or stable patterns found in 1st segment, 3rd segment and 5th segment indicates that there has been a process of deoxygenation of carbon in these segments. However, the deoxygenation process in 1st segment, 3rd segment and 5th segment is not as fast as 4th segment. This is due to the influence of the organic material entering the segments affecting the carbon deoxygenation rate in the Metro River. Organic materials from various sources of pollutants in the Metro River there are easily decomposed and there is difficult to decompose. Organic materials that enter the river body and accumulate in the river will affect the organic system that takes place in these waters which resulted in changes in dissolved oxygen content in these waters which tend to decrease (Hadinafta, 2009). In many residential and industrial segments, the decomposition process occurs faster. Meanwhile, in the segment of rice field, the decomposition process occurs longer because the organic material content is synthetic so that the organic material is difficult to be decomposed (Paramita, 2012).

In the 1st segment, 3rd segment and 5th segment, the decomposition process that occurs quite quickly that is ranged from 0.53 to 0.55/day. However, this decomposition process is not as fast as in 4th segment that is equal to 0.63/day. This is because in this 4th segment areas of settlements and rice fields are not as dense in these three segments so that the organic material into the water is less. In addition, the types of organic materials contained in 4th segment such as fat, protein, glucose, aldehyde, esters and so on quickly decompose by microorganisms so that the decomposition process in 4th segment becomes faster than other segments. In addition to differences in the amount and type of organic matter the difference in the number of bacterial decomposers can also affect the decay rate of organic matter. The higher the level of pollution by organic matter, then the number of bacteria that live in the river will also be more and more. However, the increasing number of bacteria will cause the amount of oxygen in the water will be reduced and potentially cause disruption of organism life in the river.

The smallest value of carbon deoxygenation constant (*kd*) found in 2nd segment and 5th segment shows that in 2nd segment and 5th segment the decomposition process is slow. This can be due to the organic material contained in the two segments is difficult to decompose so that the decomposition process becomes slow (Hariyadi, 2011). The small value of *kd* in 2nd segment and 5th segment is also due to the incoming pollutant load capacity exceeding the capacity of the river. As a result, the river is unable to perform self-recovery (self purification).

River water temperatures also affect carbon deoxygenation (Menezes, Bittencourt, Farias,., Bello, Oliveira, Fia, 2015). Carbon deoxygenation rates in spring compared to summer with lower flow. Water river sampling for determination of deoxygenation Carbon in this research have been done at April 2017 when the dry season.

4. Conclusion

The rate of carbon deoxygenation shows the quality performance of the river from self-recovery or self-purification of rivers. The higher the rate of carbon deoxygenation, then the self-recovery ability of the stream of organic matter is also higher. High levels of carbon deoxygenation also indicate the amount of aerobically decomposed organic material so that oxygen consumption is also high. The availability of oxygen from the river reaeration process determines also in the degree of carbon deoxygenation. The highest rate of carbon deoxygenation (*kd*) occurs in 4th segment of 0.63/day, while the smallest is in 2nd segment of 0.48/day. The carbon deoxygenation rate in Metro River is higher than Brantas River of Malang City and Upper Citarum River. It shows that Metro River has better self-recovery capability so that its quality is better too. The self-recovery capability of rivers as a water body of waste receptors is influenced by the quality of waste, river flow, temperature and reaeration processes.

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